GLOW PLUG

BACKGROUND OF THE INVENTION

1. Field of the Invention:

[01] The present invention relates to a glow plug used, for example, to preheat a diesel engine.

2. Description of the Related Art:

[02] A self-control-type glow plug will be described with reference to Fig. 2. A glow plug 1 is composed substantially of a tubular metallic shell 2 and a sheathed heater 3, which extends axially through the metallic shell 2.

[03] The sheathed heater 3 is configured as follows: A resistance wire coil 3b, which consists of a heating coil portion 30b located on the side toward the distal end of the resistance wire coil 3b and a control coil portion 300b located on the side toward the rear end of the resistance wire coil 3b, and a distal end portion of a bar electrode 3c are placed in a sheath 3a made of a heat-resisting metal. The distal end of sheath 3a is closed in a substantially hemispherical shape and is open at a rearward end thereof. The sheath 3a is filled with an insulating MgO (magnesium oxide) powder 3d, and an insulating rubber packing 3e is interposed between the bar electrode 3c and the inner surface of an opening portion of the sheath 3a to thereby seal the opening. The bar electrode 3c is disposed such that its distal end is located in a longitudinally intermediate portion of the interior of the sheath 3a and electrically connected to the resistance wire coil 3b (control coil portion 300b), whereas its rear end extends along the axis of the metallic shell 2 and projects outward therefrom. The resistance wire coil 3b (heating coil portion 30b) is electrically connected to the inner

surface of the closed distal end of the sheath 3a. Accordingly, the bar electrode 3c and the sheath 3a are electrically connected together via the resistance wire coil 3b.

[04] The resistance wire coil 3b of the self-control-type glow plug 1 is configured such that the heating coil portion 30b and the control coil portion 300b are connected in series. Mainly the heating coil portion 30b generates heat to cause the distal end of the sheath 3a to glow, whereas the control coil portion 300b rapidly increases in electric resistance with temperature to suppress current flowing to the heating coil portion 30b. As described above, in the resistance wire coil 3b, the heating coil portion 30b and the control coil portion 300b of the resistance wire coil 3b each has a respective role. A material is selected as appropriate in accordance with these roles. For example, an Fe-Cr alloy or an Ni-Cr alloy, each of which exhibits excellent resistance to oxidation and heat, is used to form the heating coil portion 30b. Also, so that its electric resistance sensitively reflects a change in temperature, pure Fe or the like, which has a high positive temperature-resistance coefficient, is used to form the control coil portion 300b (see, for example, Japanese Patent Publication (*kokoku*) No. 2-59372). In the glow plug of this patent publications, pure Fe is employed as a material for the control coil portion 300b, and, in order to enhance oxidation resistance of the pure Fe, the surface of an Fe wire is plated with Ni or Cr.

3. Problems to be Solved by the Invention:

[05] A material having excellent resistance to heat and oxidation is selected as a material for the heating coil portion 30b. However, when the temperature of the heating coil portion 30b exceeds 1,000°C, the heating coil portion 30b formed of such material fails to exhibit the expected durability. For example, in the case where the heating coil portion 30b is formed of an Fe-Cr-Al alloy, the heating coil portion 30b

must sufficiently endure a temperature of 1,000°C in terms of resistance to heat and oxidation of the alloy. However, when the heating coil portion 30b was actually manufactured from the alloy and subjected to a durability test at 1,000°C (the test method is described below), the test confirmed that the surface of the heating coil portion 30b melted with resultant breakage of the heating coil portion 3b. Occurrence of such a phenomenon is unexpected, and the cause is unknown. The present inventors presumed the cause to be that a high temperature in excess of 1,000°C caused the insulating MgO powder 3d to react in a certain way with Fe or Ni contained in an alloy used to form the heating coil portion 30b, resulting in breakage of the heating coil portion 30b.

BRIEF DESCRIPTION OF THE DRAWINGS

[06] Fig. 1 is a vertical longitudinal view of a glow plug including a partially enlarged view.

[07] Fig. 2 is a vertical longitudinal view of a conventional glow plug including a partially enlarged view.

[08] Description of Reference Numerals:

1: glow plug

2: metallic shell

3: sheathed heater

3a: sheath

3b: resistance wire coil

30b: heating coil portion

31b: coil base material

32b: coating layer

3c: bar electrode

3d: insulating powder

SUMMARY OF THE INVENTION

[09] It is therefore an object of the present invention to provide a glow plug that exhibits excellent durability at high temperature, particularly a high temperature in excess of 1,000°C.

[10] The above object of the present invention has been achieved by providing a glow plug comprising a sheathed heater and a tubular metallic shell, the sheathed heater comprising a tubular sheath having a closed distal end, a resistance wire coil disposed in the sheath and having at least a heating coil portion, an insulating MgO powder charged in the sheath, and a bar electrode having one end inserted into a rear end of the sheath in a sealed condition, the sheathed heater being inserted into a tubular hole of the metallic shell with a distal end portion of the sheath projecting outward from the metallic shell, wherein the heating coil portion comprises a coil base material and a coating layer, which covers the surface of the coil base material, and the coating layer is formed of Pt, Pd, Rh, or an alloy of two or more of Pt, Pd, and Rh.

[11] Because a high temperature in excess of 1,000°C is considered to cause the insulating MgO powder to react in a certain way with Fe or Ni contained in an alloy used to form the heating coil portion, the coil base material of the heating coil portion is coated with a coating layer formed of Pt, Pd, Rh, or an alloy of two or more of Pt, Pd, and Rh so as to prevent direct contact between MgO and the coil base material, thereby yielding a glow plug that exhibits practically sufficient durability even at a high temperature in excess of 1,000°C.

DETAILED DESCRIPTION OF THE INVENTION

[12] An embodiment of the present invention will next be described with reference to the drawings. However, the present invention should not be construed as being limited thereto. Fig. 1 is a vertical sectional view of a glow plug including a partially enlarged view.

[13] As shown in Fig. 1, a glow plug 1 is composed substantially of a tubular metallic shell 2 and a sheathed heater 3, which extends axially through the metallic shell 2.

[14] The sheathed heater 3 is configured as follows. A resistance wire coil 3b, which consists of a heating coil portion 30b located on the side toward the distal end of the resistance wire coil 3b and a control coil portion 300b located on the side toward the rear end of the resistance wire coil 3b, and a distal end portion of a bar electrode 3c are placed in a sheath 3a made of a heat-resisting metal. The distal end of sheath 3a is closed in a substantially hemispherical shape and is open at a rearward end thereof. The sheath 3a is filled with an insulating MgO powder 3d, and an insulating rubber packing 3e is interposed between the bar electrode 3c and the inner surface of an opening portion of the sheath 3a to thereby seal the opening. The bar electrode 3c is disposed such that its distal end is located in a longitudinally intermediate portion of the interior of the sheath 3a and electrically connected to the resistance wire coil 3b, whereas its rearward end extends along the axis of the metallic shell 2 and projects outward therefrom. The resistance wire coil 3b is electrically connected to the inner surface of the closed distal end of the sheath 3a. Accordingly, the bar electrode 3c and the sheath 3a are electrically connected together via the resistance wire coil 3b.

[15] The resistance wire coil 3b is configured such that the heating coil portion 30b and the control coil portion 300b are connected in series. Mainly the heating coil portion 30b generates heat to cause the distal end of the sheath 3a to glow, whereas the control coil portion 300b suppresses current flow to the heating coil portion 30b because its electric resistance increases rapidly with temperature. So that the electric resistance of the control coil portion 300b sensitively reflects a change in temperature, a material having a high positive temperature-resistance coefficient, such as pure Fe or a Co-Ni alloy, is used to form the control coil portion 300b.

[16] In order to endure high temperature, the heating coil portion 30b is configured as follows: an Fe-Cr-Al alloy or an Ni-Cr alloy, which has excellent resistance to oxidation and heat, is used as a coil base material 31b; and the surface of the coil base material 31b is coated with a coating layer 32b. The coating layer 32b is formed to be thin (preferred range of thickness: 0.2 to 0.5 μm, thickness in this embodiment: 0.3 μm) and uniform, from Pt (platinum), Pd (palladium), Rh (rhodium), or an alloy of two or more of Pt, Pd, and Rh through, for example, plating or vapor deposition. Since these metals used to form the coating layer 32b have high ductility and malleability, the coating layer 32b is unlikely to crack even when the resistance wire coil 3b undergoes a reduction in diameter in the process of swaging the sheath 3a. Incidentally, when the coating layer 32b cracks, the coil base material 31b and the insulating MgO powder 3d come into contact with each other through the crack, resulting in impaired durability at high temperature.

Durability Test:

[17] In order to confirm the effect of the present invention, five kinds of sheathed heaters 3 were fabricated as follows: an Fe-Cr-Al alloy (Fe: 66 wt.%; Cr: 26 wt.%; Al: 8 wt.%) was used as the coil base material 31b of the heating coil portion

30b; the control coil portion 300b was formed of a Co-Ni alloy (Co: 71 wt.%; Ni: 25 wt.%; Fe: 4 wt.%); and the coating layer 32b of the heating coil portion 30b was varied as No. 1 (unplated), No. 2 (Ni plating), No. 3 (Pt plating), No. 4 (Rh plating), and No. 5 (Pd plating). By use of the sheathed heaters 3, the glow plugs 1 as shown in Fig. 1 were manufactured and subjected to a durability test. The test results are shown in Table 1. In the durability test, the glow plugs 1 were continuously subjected to test cycles, each cycle consisting of application of 11 Vdc for 10 sec → application of 13 Vdc for 300 sec → OFF for 60 sec. In the durability test, the maximum temperature of the heating coil portion 30b reached about 1,100°C.

Table 1

No.	Coil base material of heating coil portion	Coating layer (plating)	Control coil portion	Breakage of wire	Performance deterioration	Durability
1	Fe-Cr-Al	Unplated	Co-Ni	x	x	x
2	Fe-Cr-Al	Ni	Co-Ni	Δ	x	x
3	Fe-Cr-Al	Pt	Co-Ni	o	o	o
4	Fe-Cr-Al	Rh	Co-Ni	o	o	o
5	Fe-Cr-Al	Pd	Co-Ni	o	o	o

[18] In the "Breakage of wire" column of Table 1, "x" denotes that complete wire breakage was observed; "Δ" denotes that an indication of wire breakage was observed; and "o" denotes that no indication of wire breakage was observed.

[19] The symbol "x" in the "Performance deterioration" column denotes that, after being subjected to a predetermined number of test cycles (5,000 cycles or more), the heating temperature dropped by 100°C or more as compared with that

measured at the beginning of the test.

[20] The "Durability" column shows an overall evaluation based on the results of "Breakage of wire" and "Performance deterioration." In the "Durability" column, "x" denotes that a problem exists in terms of durability, and "o" denotes that no problem exists in terms of durability.

[21] As is apparent from the results shown in Table 1, glow plugs Nos. 3 to 5, which correspond to embodiments of the present invention, exhibited excellent durability as compared with glow plugs Nos. 1 and 2. Notably, in the case of glow plug No. 2, in which the coil base material 31b was plated with Ni, deteriorated performance conceivably was the result of alloying of Ni and the coil base material 31b.

[22] Although the present invention has been described with reference to the above embodiment, the present invention is not limited thereto. For example, the above embodiment is described while mentioning the self-control-type glow plug 1; however, the present invention is also applicable to a glow plug that does not include the control coil portion 300b; e.g., to a glow plug in which the entire resistance wire coil 3b serves as the heating coil portion 30b.

[23] The gist of the present invention resides in the structure of the heating coil portion 30b. Therefore, no particular limitation is imposed on the structure of the control coil portion 300b.

Effect of the Invention:

[24] At high temperatures in excess of 1,000°C, a heating coil portion of a resistance wire coil fails to exhibit expected durability even though a material used to form the heating coil portion has sufficient resistance to heat and oxidation. In studying this phenomenon, the present inventors discovered that by coating a coil

base material of the heating coil portion with a coating layer, a glow plug is obtained that exhibits practically sufficient durability even at high temperatures in excess of 1,000°C. Therefore, the present invention is highly useful for implementing a glow plug that exhibits excellent durability at high temperature, particularly at high temperatures in excess of 1,000°C.

[25] It should further be apparent to those skilled in the art that various changes in form and detail of the invention as shown and described above may be made. It is intended that such changes be included within the spirit and scope of the claims appended hereto.

[26] This application is based on Japanese Patent Application 2003-055392 filed March 3, 2003, incorporated herein by reference in its entirety.